Chapter 10
A Virtual Simulator for the Embedded Control System Design for Navigation of Mobile Robots Applied in Wheelchairs

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ABSTRACT

This chapter presents a virtual environment implementation for embedded design, simulation, and conception of supervision and control systems for mobile robots, which are capable of operating and adapting to different environments and conditions. The purpose of this virtual system is to facilitate the development of embedded architecture systems, emphasizing the implementation of tools that allow the simulation of the kinematic, dynamic, and control conditions, in real time monitoring of all important system points. To achieve this, an open control architecture is proposed, integrating the two main techniques of robotic control implementation at the hardware level: systems microprocessors and reconfigurable hardware devices. The utilization of a hierarchic and open architecture, distributing the diverse actions of control in increasing levels of complexity and the use of resources of reconfigurable computation are made in a virtual simulator for mobile robots. The validation of this environment is made in a nonholonomic mobile robot and in a wheelchair; both of them used an embedded control rapid prototyping technique for the best navigation strategy implementation. After being tested and validated in the simulator, the control system is programmed in the control board memory of the mobile robot or wheelchair. Thus, the use of time and material is optimized, first validating the entire model virtually and then operating the physical implementation of the navigation system.

INTRODUCTION

This work's main objective is to present an implementation of a virtual environment for rapid design and simulation prototyping. The conception of supervision and control systems for mobile robots are also discussed. Mobile robot platforms are capable of operating and adapting themselves to different environments and conditions. The purpose of this virtual system is to facilitate the development of embedded architecture systems, emphasizing the implementation of tools that allow the simulation of the kinematic, dynamic, and control conditions, with real-time monitoring of all important system points. To accomplish these tasks, this work proposes an open control architecture that integrates the two main techniques of robotic control implementation at the hardware level: microprocessor systems and reconfigurable hardware devices, like a CPLD (Complex Programmable Logic Device). The utilization of a hierarchic and open architecture, distributing the diverse actions of control on increasing levels of complexity, the use of resources of reconfigurable computation, and the validation of this environment are made in a virtual simulator for mobile robots (Normey-Ricoa, et al., 1999).

Locomotion planning, under some types of restrictions, is a very vast field of research in the field of the mobile robotics (Siegwart & Nourbakhsh, 2004). The basic planning of trajectory for mobile robots implies the determination of a way in the space-C (configuration space), between an initial configuration and the final configuration, in such way that the robot does not collide with any obstacle in the environment, and that the planned movement is consistent with the kinematic restrictions of the vehicle (Graf, 2001). In this context, one of the points boarded in this work was the development of a trajectory calculator for mobile robots.

The implemented simulator system is composed of a module of a trajectory generator, a kinematic and dynamic simulator module, and an analysis module for results and errors. The simulator was implemented from the kinematic and dynamic model of mechanical drive systems of the robotic axles and can be used to simulate different control techniques in the field of mobile robotics, allowing the simulator system to deepen the concepts of navigation systems, trajectory planning, and embedded control systems. All the kinematic and dynamic results obtained during the simulation can be evaluated and visualized in graphs and table formats in the results analysis module, allowing the system to minimize errors using necessary adjustments and optimizations (Antonelli, et al., 2007).

The controller implementation in the embedded system uses a rapid prototyping technique, which allows, along with the virtual simulation environment, the development of a controller design for mobile robots. After being tested and validated in the simulator, the control system is programmed into the memory of the embedded mobile robot board. In this way, time and material are economized by first virtually validating the entire model and then operating the physical implementation of the system.

The hardware and mechanical validation and the tests were accomplished with a nonholonomic prototype of the mobile robot model with a differential transmission.

THE MOBILE ROBOT PLATFORM

This chapter presents the implementation of a virtual environment for simulation and conception of supervision and control systems for mobile robots and is focuses on the study of the mobile robot platform, with differential driving wheels mounted on the same axis and a free castor front wheel, whose prototype is used to validate the proposal system, as depicted in Figure 1.

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